AD-A159 524 A COMPUTER PROGRAM FOR ANALYSIS OF FUELWOOD HARVESTING COSTS(U) FOREST PRODUCTS LAB MADISON WI G B HARPOLE ET AL. OCT 85 FPL-46 1/1

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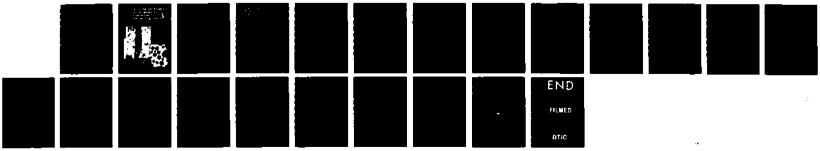

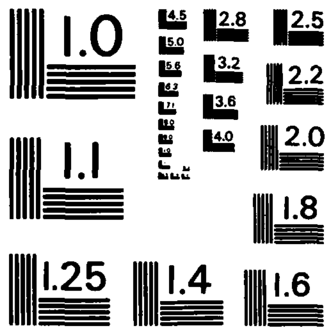

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Report FPL-46

A Computer Program for Analysis of Fuelwood Harvesting Costs

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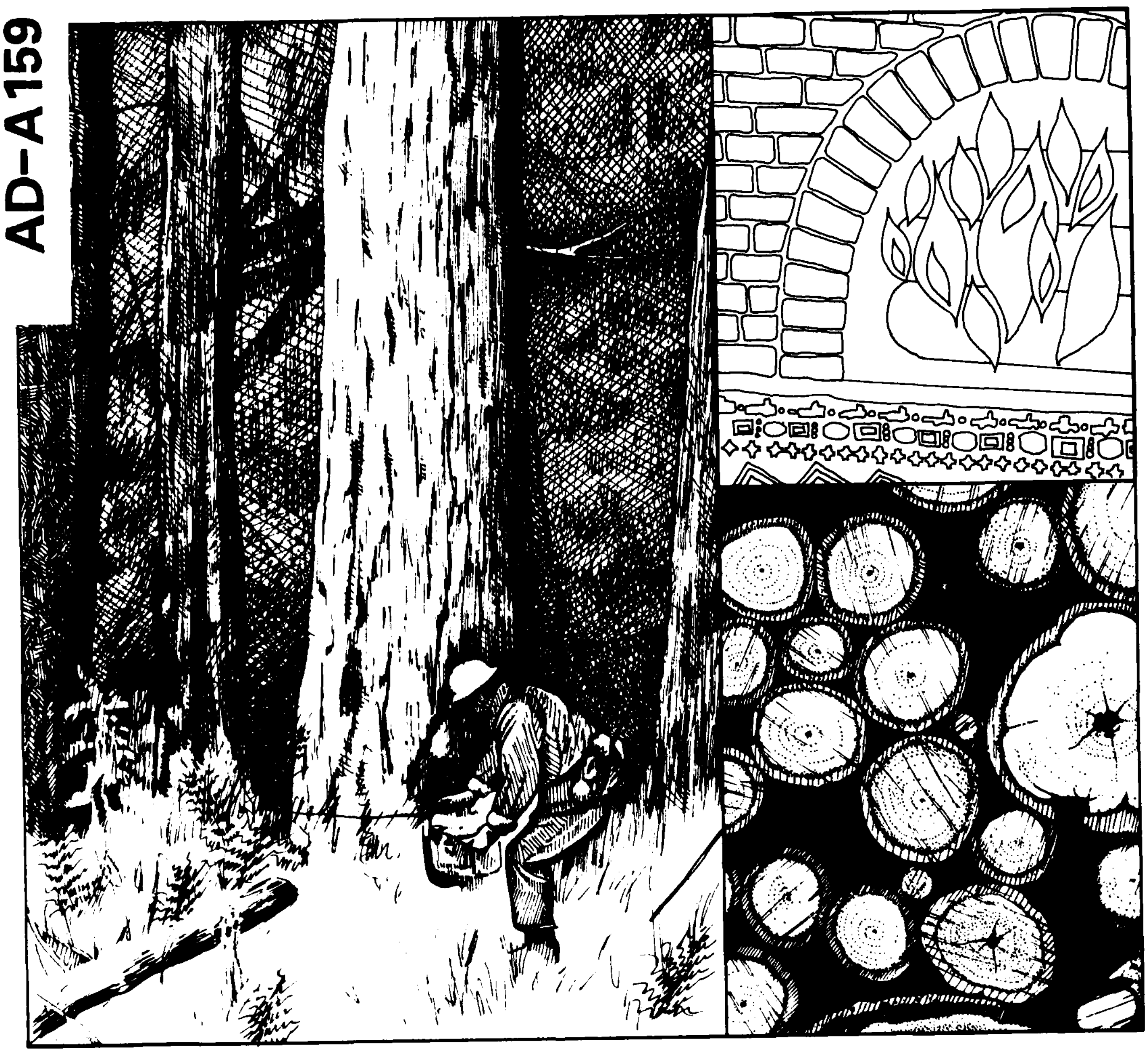

Abstract

The fuelwood harvesting computer program (FHP) is written in FORTRAN 60 and designed to select a collection of harvest units and systems from among alternatives to satisfy specified energy requirements at a lowest cost per million Btu's as recovered in a boiler, or thousand pounds of H_2O evaporative capacity kiln drying. Computed energy costs are used as a criterion of economic viability. Sensitivities of energy costs and fuel requirements to changes in moisture content are computed and provided in the printed output.

Keywords: Wood/bark fuel, harvesting, economics, computer program.

October 1985

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A Computer Program for Analysis of Fuelwood Harvesting Costs

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Introduction

Forest residues represent an abundant wood source often unutilized because of the inability of market prices to support costs for harvesting. In some circumstances, however, harvesting forest residues for fuel may be combined with harvesting of wood-chip and cull-log products to offer economic and environmentally desirable utilization of forest residues. The fuel harvest analysis computer program (FHP) is designed to select harvest units and harvest systems from a number of alternatives to satisfy specific energy requirements, at a lowest cost per million Btu's as recovered in a boiler (as exemplified in fig. 1), or per thousand pounds of H_2O evaporative capacity for kiln drying (as exemplified in fig. 2). The energy costs so computed can then be used as a criterion for economic viability of various harvesting options.

The FHP computer program given in the appendix is written in FORTRAN 60 for use by forestry planners, business analysts, and utilization economists. The program is designed for application to logging operations where the following conditions apply:

- year-round headquarters are maintained for business management and equipment storage and repair,
- harvesting opportunities are available at different harvest sites and wood supplies may collectively exceed fuel product demand and harvesting capacities,
- prospective harvest units may have different cost requirements for construction of roads and landings,
- alternative harvesting systems may be employed at any harvest unit for production of different product mixes of fuel and other marketable products.

Structure of the FHP computer program follows standard accounting practices. Computed energy costs are residual costs, i.e. the net amount of costs and revenues from marketable products are a residual cost which may be negative in situations where revenues exceed all costs. Costs for risk and/or requirements for profit on working capital may be included. Marginal cost analyses may be accomplished by representing a harvest unit as a series of different intensities of possible harvesting. For all analyses, sensitivities of energy costs and fuel requirements to changes in moisture content are computed and provided in the printed output (figs. 1 and 2).

Data Input Requirements

Use of the FHP computer program requires good estimates of costs per hour for each operable harvesting system considered, and good estimates of the number of operating hours required per acre of harvest area. The entries for generation of the problem specification and printed output of figures 1 and 2 are derived from data coding worksheets (figs. 3 and 4). Input requirements for these worksheets are described below:

Card Type 1: Title card (fig. 3) for captioning printed output (first card in data deck).

Card Type 2: Program constants (fig. 3) (second card in data deck).

Cols. 2-3: *Number of Harvest Units*. Enter number of harvest units to be considered, up to 50 harvest units.

Cols. 7-10: *Stack Temperature*. Enter in degrees Fahrenheit (at least 100°), for computation of costs per million Btu's of steam. A stack temperature of 375°F is typical. If no entry is made, the program computes costs per thousand pounds of H_2O evaporative capacity of stack gases (1,700 Btu's per pound of water evaporated as in a dry kiln). Boiler efficiency calculations assume 40 percent excess air and 4 percent heat loss from unburned fuel, radiation, and unaccounted heat losses.[1] The equations used for computation of boiler efficiencies are shown in table 1.

Table 1.—Equations used for computation of boiler efficiencies

Range of moisture content (wet basis) From	To	Boiler efficiency (BE) versus Moisture content fraction, wet basis (MCW) and Stack temperature in fahrenheit (°F) (ST)
0	0.285	BE = 0.9350 − (MCW * 0.18182) − (ST * 0.000310)
0.286	0.443	BE = 1.0019 − (MCW * 0.35454) − (ST * 0.000345)
0.444	0.545	BE = 1.0920 − (MCW * 0.51232) − (ST * 0.000385)
0.545	0.614	BE = 1.3128 − (MCW * 0.87770) − (ST * 0.000410)
0.615	greater	BE = 1.4646 − (MCW * 1.09615) − (ST * 0.000445)

Cols. 11-20: *Annual Heating Requirements*. Enter in millions of Btu's if stack temperature is specified, otherwise in number of pounds (in thousands) of H_2O to be evaporated annually.

Cols. 23-30: *Fixed Cost*. Enter the annual costs for headquarter operations, i.e. for business management, equipment storage and repair, etc.

Cols. 34-35: *Number of Weeks for Working Capital*. Enter average time in weeks, from actual payout for wages, supplies, etc., until cash returns are realized from sale of products and/or to time fuel is burned.

[1]Corder, S. F. Wood and bark as fuel. School of Forestry Research Bulletin 14. Corvallis, OR: Oregon State University; 1973.

Cols. 41-45: *Risk-Profit Requirement*. Enter a decimal fraction amount to indicate desired or alternative rate-of-return for investments.

Card Type 3: Harvest unit data card (fig. 3). One card must be prepared for each harvest unit to be considered. Harvest system data cards (card type 4) and harvest system's product data cards (card type 5) will be assembled in filing fashion following each corresponding harvest unit card (card type 3).

Col. 1: Enter "U" to identify Card as a harvest unit data card.

Cols. 2-3: *Harvest Unit Number*. Enter the sequential number of the harvest unit.

Cols. 5-10: *Harvest Unit Name*. Enter any alphanumeric captioning for the harvest unit.

Cols. 15-20: *Unit's Unit Measure*. Enter unit of measure used for harvest area's wood/bark materials, such as "cubic feet," "MBF," "Scribner," etc.

Cols. 24-30: *Harvest Unit's Acres*. Enter the total number of acres to be harvested in the harvest unit.

Cols. 34-40: *Units per Acre*. These units must correspond to the unit of measure entered in Cols. 15-20.

Cols. 44-50: *Unit's Fixed Cost*. Enter the estimated fixed cost for putting the harvest unit into condition suitable for harvesting operations. This amount should include costs for landings, roads, lump sum amounts for stumpage, and the like.

Cols. 54-55: *Number of Systems*: Alternative harvesting systems may be considered for each harvest unit, each with different operating costs per hour and product mix. Data for each system will follow. The number of alternative systems to be considered must be entered here.

Cols. 59-64: *Cubic Feet per Unit*. Enter the number of cubic feet of solid wood/bark per unit of measure used. If cubic feet is the unit of measure then 1.0 must be entered. If MBF (thousand board feet) is entered, then an appropriate figure somewhere between 160.0 and 225.0 should probably be entered—representing the number of cubic feet of solid wood per MBF.

Card Type 4: Harvest system data (fig. 4). Prepare one harvest system data card for each system considered for a harvest unit.

Col. 1: Enter "S" to identify the card as a system card.

Cols. 2-3: *System's Number*. Enter the sequential number for each system alternative.

Cols. 5-10: *System's Name*. Enter any alpha-numeric captioning desired for the system.

Cols. 14-15: *Number of Products*. Enter the number of different kinds of product expected to be produced by the system.

Cols. 16-20: *Hours per Acre*. Enter the average number of operating hours required to harvest an acre of the harvest unit.

Cols. 24-30: *System's Variable Cost*. Enter the cost per hour of operating the system.

Cols. 31-50: *Fuel Description*. Enter any alpha-numeric caption to describe the fuel type, e.g. chips, cordwood, etc.

Cols. 61-65: *Moisture Content*. Enter in decimal fraction the moisture content of fuel, wet basis, as fired.

Cols. 66-70: *Specific Gravity*. Enter in decimal fraction the specific gravity of the fuel product.

Cols. 71-75: *Higher Heating Value*. Enter the higher heating value in thousands of Btu's per ovendry pound of wood bark fuel type.

Card Type 5: Harvest system's product data (fig. 4). Use one card for each product. Up to 10 products, including fuel, may be considered.

Col. 1: Enter "F" for identification of the first card in the product list, which must have data for the fuel to be harvested.

Cols. 2-3: *Fuel Product Number*. Enter the sequential number for each product.

Cols. 5-10: *Fuel Name*. Enter any alpha-numeric designation for captioning printed output.

Cols. 15-20: *Fuel, Product Percentages*. Enter the percent of solid wood bark expected to be realized from total harvest by each product. Percentages for all products, including fuel, must add to 100.0 percent.

Cols. 25-30: *Product's Unit*. Enter any alpha-numeric code for printed output captioning.

Cols. 34-40: *Cubic Feet of Product, per Unit*. Enter the number of cubic feet of solid wood/bark per nominal unit given to each product.

Cols. 44-50: *Variable Cost*. Enter cost in dollars per unit, associated directly with production (stumpage, chipping, etc.) and delivery of the product type to point where no further product-associated costs will accrue.

Cols. 54-60: *Market Value*. Enter realization per unit (selling price less all discounts, allowances, etc.) anticipated from the product type, if product is intended for sale. No value should be entered if the product is the fuel for which a cost is to be computed.

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HARVEST ANALYSIS FOR MINIMIZING FUEL COST PER MILLION BTU



PROBLEM SPECIFICATIONS

     NUMBER OF HARVEST UNITS                              2
     STACK GAS TEMPERATURE          (DEGREES F)         350.
     ANNUAL HEAT REQUIREMENT        (     MMBTU)    1160000.
     OVERHEAD FIXED COSTS           (   DOLLARS)      80000.
     WORKING CAPITAL REQUIREMENT    (     WEEKS)          8
     RISK-PROFITPERCENT REQ.T                            .20

NOTE: IF STACK GAS TEMPERATURE ENTERED IS LESS THAN 100. DEGREES F., COSTS PER THOUSAND POUNDS OF H2O
      EVAPORATIVE CAPACITY WILL BE CALCULATED AS FOR DIRECT-FIRED KILN USE. ANNUAL HEAT REQUIREMENTS
      MUST BE ENTERED AS NUMBER OF THOUSAND POUNDS OF H2O TO BE REMOVED FROM LUMBER THROUGH KILN.



HARVEST UNIT JUNIPR    1    ACRES                        5000.0   TOTAL CU. FT. AVAIL      5000.0M
INPUT SEQUENCE NO.     1    VOL./ACRE IN  CU FT          1000.0   CU. FT., SOLID/UNIT         1.0
NO. HARVEST SYSTEMS    1    HARVEST UNIT FIXED COSTS     5000.
```

SYSTEM	HRS/ ACRE	COST/ HOUR	PROD CODE	PERCENT TOTAL RECOV	UNIT NAME	SOLID CU.FT./ UNIT	UNITS AVAILABLE	PREP COST/ UNIT	MKT VAL/ UNIT	MOIS CONT	MMBTU AVAILABLE	COST/ UNIT	MBTU/ UNIT	VAR. COST/ MMBTU
JUNIPR 1	3.50	200.	FUEL	100.00	FUNIT	72.00	69444.	7.50	.00	.26	912089.	57.90	13134.08	4.41

```
          *** LEAST COST HARVEST SYSTEM  JUNIPR  1 ***
                   HARVEST UNIT  JUNIPR  1

          -FUEL-                     -ENERGY-

     UNITS AVAIL       69444.    MMBTU AVAIL     912089.
     FIXED COST         5000.    COST/MMBTU         4.41
     TOTAL COST/UNIT     57.97

NOTE---M IS THOUSANDS, MM IS MILLIONS.
   ---''TOTAL COST/UNIT'' INCLUDES HARVEST UNIT FIXED COST, BUT DOES NOT INCLUDE ''OVERHEAD FIXED COST'', OR COST (INTEREST)
        FOR WORKING CAPITAL REQUIREMENT.
```

Figure 1.—Example of harvesting cost analysis per million Btu's.

```
HARVEST UNIT OLD GR    2    ACRES                            2000.0   TOTAL CU. FT. AVAIL      6400.0M
INPUT SEQUENCE NO.     2    VOL./ACRE IN  MBF                  20.0   CU. FT., SOLID/UNIT       160.0
NO. HARVEST SYSTEMS    2    HARVEST UNIT FIXED COSTS   35000.
```

SYSTEM	HRS/ ACRE	COST/ HOUR	PROD CODE	PERCENT TOTAL RECOV	UNIT NAME	SOLID CU.FT./ UNIT	UNITS AVAILABLE	PREP COST/ UNIT	MKT VAL/ UNIT	MOIS CONT	MMBTU AVAILABLE	COST/ UNIT	MBTU/ UNIT	VAR. COST/ MMBTU
OLD GR 1	5.50	250.	FUEL	25.00	FUNIT	72.00	22222.	7.50	.00	.29	279841.	-58.47	12592.86	-4.64
			LOGS 1	15.00	MBF	160.00	6000.	.00	200.00					
			LOGS 2	20.00	MBF	160.00	8000.	.00	145.00					
			PCHIPS	40.00	BDU	100.00	25600.	7.50	80.00					
OLD GR 2	5.00	200.	FUEL	100.00	FUNIT	72.00	88889.	7.50	.00	.29	1119365.	30.00	12592.86	2.38

```
*** LEAST COST HARVEST SYSTEM  OLD GR  1 ***
              HARVEST UNIT  OLD GR  2

   -FUEL-                              -ENERGY-

UNITS AVAIL         22222.    MMBTU AVAIL     279841.
FIXED COST          35000.    COST/MMBTU         -4.52
TOTAL COST/UNIT     -56.89

NOTE---M IS THOUSANDS, MM IS MILLIONS.
   ---''TOTAL COST/UNIT'' INCLUDES HARVEST UNIT FIXED COST, BUT DOES NOT INCLUDE ''OVERHEAD FIXED COST'', OR COST (INTEREST)
        FOR WORKING CAPITAL REQUIREMENT.

                    HARVEST ANALYSIS FOR MINIMIZING FUEL COST PER MILLION BTU

********** FUEL TYPE ASSUMPTIONS AND ESTIMATES OF REQUIREMENTS AND COSTS ( 350. DEG.F STACK TEMP.) **********

                              **** HEAT ENERGY SOURCES AND COSTS ****
```

	UNIT BASIS	UNITS AVAIL. ANNUALLY	CU.FT. SOLID	SPEC. GRAV.	M.C. (WET)	$ COST PER UNIT	----HEAT-ENERGY VALUES---- HIGHER VALUE MBTU/UNIT	HEAT TO STEAM MBTU/UNIT	$/MMBTU
PROPOSED SOURCE(S)									
1) FUEL CHIPS-MIXED	FUNIT	22222.	72.00	.400	.2900	$ -56.89	16179.	12592.86	$ -4.52
2) FUEL CHIPS-JUNIPER	FUNIT	69444.	72.00	.400	.2800	$ 57.97	16934.	13134.08	$ 4.41

```
NOTE---M IS THOUSANDS, MM IS MILLIONS.
```

Figure 1.—Example of harvesting cost analysis per million Btu's.—con.

HARVEST ANALYSIS FOR MINIMIZING FUEL COST PER MILLION BTU

**** PROSPECTUS REQUIREMENTS (1160000. MILLION STEAM-HEAT BTU S/YEAR) AND AVERAGE COST/MMBTU ****

--------ANNUAL VOLUMES REQUIRED AT VARIOUS MOISTURE CONTENTS (WET BASIS)--------

PROPOSED SOURCES	UNIT BASIS	AT GIVEN M.C.	AT HIGHER MOISTURE CONTENT* +5 PCT.	+10 PCT.	+20 PCT.	AT LOWER MOISTURE CONTENT** -5 PCT.	-10 PCT.	-20 PCT.
1) FUEL CHIPS-MIXED	FUNIT	22222.2	22222.2	22222.2	22222.2	22222.2	22222.2	22222.2
2) FUEL CHIPS-JUNIPER	FUNIT	68536.1	69444.4	69444.4	69444.4	67619.5	66601.9	64635.1
AVG. COST/MMBTU		$ 2.52	$ 2.58	$ 2.64	$ 2.78	$ 2.47	$ 2.42	$ 2.32
EST.D TOTAL COSTS		$2972.7M	$*******M	$*******M	$*******M	$2916.9M	$2854.9M	$2735.3M
WORKING CAPITAL REQ		$ 919.4M	$ 933.1M	$ 933.1M	$ 933.1M	$ 905.8M	$ 890.9M	$ 862.9M

* WOOD FUEL CALCULATIONS ASSUME 40-PCT EXCESS AIR AND 4-PCT HEAT LOSS FROM UNBURNED FUEL, RADIATION AND UNACCOUNTED LOSSES. THE PROGRAM ALLOWS WOOD FUEL MOISTURE CONTENTS TO DROP BELOW 0-PCT BUT DISQUALIFIES A FUEL TYPE WHEN MOISTURE CONTENT EXCEEDS 65-PCT.

******** DUE TO A BTU DEFICIT, THIS CALCULATION IS NOT MEANINGFUL.

**** WITH MOISTURE CONTENT CHANGED 10 PCT. (WET BASIS), THERE IS AN ANNUAL DEFICIT OF 7895.2 MMBTU'S ****
**** WITH MOISTURE CONTENT CHANGED 20 PCT. (WET BASIS), THERE IS AN ANNUAL DEFICIT OF 35115.6 MMBTU'S ****
**** WITH MOISTURE CONTENT CHANGED -5 PCT. (WET BASIS), THERE IS AN ANNUAL DEFICIT OF 89562.2 MMBTU'S ****

NOTE---M IS THOUSANDS, MM IS MILLIONS.
---COSTS INCLUDE ''OVERHEAD COST'' AND WORKING CAPITAL COST(INTEREST).

Figure 1.—Example of harvesting cost analysis per million Btu's.—con.

```
              HARVEST ANALYSIS FOR MINIMIZING FUEL COST PER THOUSAND LBS. OF EVAP. H2O



PROBLEM SPECIFICATIONS

     NUMBER OF HARVEST UNITS                          2
     STACK GAS TEMPERATURE        (DEGREES F)         0.
     ANNUAL HEAT REQUIREMENT      (     M#H2O,   690000.
     OVERHEAD FIXED COSTS         (  DOLLAR')     80000.
     WORKING CAPITAL REQUIREMENT  (     WEEKS)        8
     RISK-PROFITPERCENT REQ.T                       .20

NOTE: IF STACK GAS TEMPERATURE ENTERED IS LESS THAN 100. DEGREES F., COSTS PER THOUSAND POUNDS OF H2O
      EVAPORATIVE CAPACITY WILL BE CALCULATED AS FOR DIRECT-FIRED KILN USE. ANNUAL HEAT REQUIREMENTS
      MUST BE ENTERED AS NUMBER OF THOUSAND POUNDS OF H2O TO BE REMOVED FROM LUMBER THROUGH KILN.



HARVEST UNIT JUNIPR    1    ACRES                       5000.0   TOTAL CU. FT. AVAIL     5000.0M
INPUT SEQUENCE NO.     1    VOL./ACRE IN  CU FT         1000.0   CU. FT., SOLID/UNIT        1.0
NO. HARVEST SYSTEMS    1    HARVEST UNIT FIXED COSTS    5000.


 SYSTEM     HRS/  COST/  PROD   PERCENT  UNIT   SOLID      UNITS   PREP   MKT   MOIS   MMBTU      COST/     MBTU/    VAR.
            ACRE  HOUR   CODE    TOTAL   NAME   CU.FT./ AVAILABLE  COST/  VAL/  CONT  AVAILABLE   UNIT      UNIT     COST/
                                 RECOV          UNIT               UNIT   UNIT                                       M#H2O

JUNIPR 1    3.50   200.  FUEL    100.00 FUNIT   72.00      69444.  7.50    .00   .28   580529.    57.90     8359.62  6.93

              *** LEAST COST HARVEST SYSTEM  JUNIPR  1 ***
                        HARVEST UNIT  JUNIPR  1

              -FUEL-                     -ENERGY-

          UNITS AVAIL      69444.   MMBTU AVAIL    580529.
          FIXED COST        5000.   COST/MMBTU        6.93
          TOTAL COST/UNIT    57.97

NOTE---M IS THOUSANDS, MM IS MILLIONS.
   ---''TOTAL COST/UNIT'' INCLUDES HARVEST UNIT FIXED COST, BUT DOES NOT INCLUDE ''OVERHEAD FIXED COST'', OR COST (INTEREST)
        FOR WORKING CAPITAL REQUIREMENT.
```

Figure 2.—Example of harvesting cost analysis per thousand pounds of water evaporative capacity.

```
HARVEST UNIT OLD GR    2    ACRES                        2000.0   TOTAL CU. FT. AVAIL      6400.0M
INPUT SEQUENCE NO.     2    VOL./ACRE IN  MBF              20.0   CU. FT., SOLID/UNIT       160.0
NO. HARVEST SYSTEMS    2    HARVEST UNIT FIXED COSTS    35000.


  SYSTEM    HRS/  COST/  PROD    PERCENT  UNIT    SOLID     UNITS    PREP   MKT    MOIS    MMBTU      COST/     MBTU/   VAR.
            ACRE  HOUR   CODE     TOTAL   NAME   CU.FT./  AVAILABLE  COST/  VAL/   CONT  AVAILABLE    UNIT      UNIT    COST/
                                  RECOV           UNIT               UNIT   UNIT                                       M#H2O

OLD GR 1    5.50   250.  FUEL      25.00 FUNIT   72.00     22222.    7.50     .00   .29   175269.    -58.47    7887.08 -7.41
                         LOGS 1    15.00 MBF    160.00      6000.     .00  200.00
                         LOGS 2    20.00 MBF    160.00      8000.     .00  145.00
                         PCHIPS    40.00 BDU    100.00     25600.    7.50   80.00

OLD GR 2    5.00   200.  FUEL     100.00 FUNIT   72.00     88889.    7.50     .00   .29   701074.     30.00    7887.08  3.80

              *** LEAST COST HARVEST SYSTEM  OLD GR  1 ***
                      HARVEST UNIT  OLD GR  2

              -FUEL-                    -ENERGY-

           UNITS AVAIL       22222.   MMBTU AVAIL     175269.
           FIXED COST        35000.   COST/MMBTU          -7.21
           TOTAL COST/UNIT     -56.89


NOTE---M IS THOUSANDS, MM IS MILLIONS.
    ---''TOTAL COST/UNIT'' INCLUDES HARVEST UNIT FIXED COST, BUT DOES NOT INCLUDE ''OVERHEAD FIXED COST'', OR COST (INTEREST)
         FOR WORKING CAPITAL REQUIREMENT.


                    HARVEST ANALYSIS FOR MINIMIZING FUEL COST PER THOUSAND LBS. OF EVAP. H2O


              ********** FUEL TYPE ASSUMPTIONS AND ESTIMATES OF REQUIREMENTS   AND   COSTS      **********

                                    **** HEAT ENERGY SOURCES AND COSTS ****

                                                                           ----HEAT-ENERGY VALUES----
                    UNIT      UNITS AVAIL.   CU.FT.    SPEC.     M.C.     $ COST    HIGHER VALUE    EFFECTIVE EVAPORATION
                    BASIS       ANNUALLY     SOLID     GRAV=    (WET)    PER UNIT    MBTU/UNIT       #H2O/UNIT     $/M#H2O

PROPOSED SOURCE(S)
1)  FUEL CHIPS-MIXED    FUNIT     22222.     72.00     .400     .2900   $ -56.89      16179.         7887.08    $    -7.21
2)  FUEL CHIPS-JUNIPER  FUNIT     69444.     72.00     .400     .2800   $  57.97      16934.         8359.62    $     6.93

NOTE---M IS THOUSANDS, MM IS MILLIONS.
```

Figure 2.—Example of harvesting cost analysis per thousand pound of water evaporative capacity.—con.

HARVEST ANALYSIS FOR MINIMIZING FUEL COST PER THOUSAND LBS. OF EVAP. H2O

**** PROSPECTUS REQUIREMENTS (690000.   THOUSAND POUNDS OF EVAPORATED WATER/YEAR) AND AVERAGE COST/M H2O ****

--------ANNUAL VOLUMES REQUIRED AT VARIOUS MOISTURE CONTENTS (WET BASIS)--------

PROPOSED SOURCES	UNIT BASIS	AT GIVEN M.C.	AT HIGHER MOISTURE CONTENT* +5 PCT.	+10 PCT.	+20 PCT.	AT LOWER MOISTURE CONTENT** -5 PCT.	-10 PCT.	-20 PCT.
1) FUEL CHIPS-MIXED	FUNIT	22222.2	22222.2	22222.2	22222.2	22222.2	22222.2	22222.2
2) FUEL CHIPS-JUNIPER	FUNIT	61573.6	63304.9	65408.3	69444.4	60123.5	58891.4	56910.1
AVG. COST/M*H2O		$ 3.69	$ 3.85	$ 4.03	$ 4.48	$ 3.57	$ 3.46	$ 3.29
EST.D TOTAL COSTS		$2549.5M	$2654.5M	$2782.3M	$*******M	$2461.6M	$2387.1M	$2267.4M
WORKING CAPITAL REQ		$ 821.3M	$ 844.5M	$ 873.8M	$ 933.1M	$ 802.5M	$ 786.9M	$ 762.6M

* CALCULATIONS ASSUME A KILN EVAPORATIVE RATE OF 1,700 M BTUS PER POUND OF EVAPORATED WATER. EFFECTIVE EVAPORATIVE CAPACITIES FOR WOOD/BARK FUELS ARE ADJUSTED FOR FUEL MOISTURE CONTENT. THE PROGRAM ALLOWS WOOD FUEL MOISTURE CONTENT TO DROP BELOW ZERO-PCT BUT DISQUALIFIES A FUEL TYPE WHEN MOISTURE CONTENT EXCEEDS 65-PCT.

******** DUE TO A BTU DEFICIT, THIS CALCULATION IS NOT MEANINGFUL.

**** WITH MOISTURE CONTENT CHANGED -5 PCT. (WET BASIS), THERE IS AN ANNUAL DEFICIT OF   14205.9 MMBTU'S ****

NOTE---M IS THOUSANDS, MM IS MILLIONS.
    ---COSTS INCLUDE ''OVERHEAD COST'' AND WORKING CAPITAL COST(INTEREST).

Figure 2.—Example of harvesting cost analysis per thousand pounds of water evaporative capacity.—con.

Estimates prepared by ____________ Comments ____________

Project ____________

CARD TYPE 1: Title card. First card only, columns 2 through 72.

Data entry	

CARD TYPE 2: Program constants. Second card only.

Data description	Number of Harvest Units NHU (I2)	Stack Temperature STKT (F4.0)	Annual Heating Requirement AHR (F10.0)	Fixed Cost FCO (F8.0)	Number of Weeks for Working Capital NWC (I2)	Risk-profit Requirement RPR (F5.2)	Card
Cols.	2-3	7-10	11-20	23-30	34-35	41-45	
Data entry							

CARD TYPE 3: Harvest unit data. One card per harvest unit.

Data description	Enter "U" (A1)	Harvest Unit Number HUNO (I2)	Harvest Unit Name HUNME (A6)	Unit's Unit Meas. HYVU (A6)	Harvest Unit's Ac. ACRES (F7.0)	Unit's Vol. per acre VPA (F7.0)	Unit's Fixed Cost HUFC (F7.0)	Number of Systems NHS (I2)	Cu. Ft. per Harvest Unit HYCF (F6.1)	Card
Cols.	1	2-3	5-10	15-20	24-30	34-40	44-50	54-55	59-64	
Data entry	U									

Figure 3.—Fuel harvesting analysis: data coding record.

FHA DATA WORKSHEET
SYSTEM & PRODUCT DATA FOR HARVEST UNIT: ____________

CARD TYPE 4: Harvest system data. One card per harvest system.

Data description	Enter "S" (A6)	System's Number HSNO (I2)	System's Name HSNME (A6)	Number of Products NPR (I2)	Hours per Acre HPA (F5.2)	System's Var. Cost HSVC (F7.0)	Fuel Description WDBK (A20)	Moisture Content PHYS(2) (F5.4)	Specific Gravity PHYS (3) (F5.4)	Higher Heating Value (MMBTU) PHYS(4) (F5.2)	Card
Cols.	1	2-3	5-10	14-15	16-20	24-30	31-50	61-65	66-70	71-75	
Data entry	S										

CARD TYPE 5: Harvest system's product data. One card per product. (One fuel product only, 10 total)

Data description	Enter F: Fuel P: Product	Fuel Prod. Number FPNO (I2)	Fuel Name FNME (A6)	Fuel, Prod. Percentages FPP (F6.2)	Product's Unit FPU (A6)	Cu. Ft. Prod., per Unit PRCF (F7.0)	Variable Cost FPVC (F7.0)	Market Value FMV (F7.0)	Card
Cols.	1	2-3	5-10	15-20	25-30	34-40	44-50	54-60	
Data entry	F								
	P								
	P								
	P								
	P								
	P								
	P								

Figure 4 —Fuel harvesting analysis: worksheet.

```
C          FUEL HARVEST PROGRAM
C           BY GEORGE HARPOLE
C                   AND
C               GIUSEPPE REUSI
C        FOREST PRODUCTS LABORATORY
C        P.O. BOX 5130
C        MADISON,WI  53705
C        COMMERCIAL PHONE:  608/264-5761
C        FTS PHONE:  364-5761
C
      DIMENSION PNME(1,10), PNO(1,10), PP(1,10), PUNME(1,10),
     +          VUEQ(1,10), PPVC(1,10), MV(1,10) , PUCF(1,10)
     +,PUAV(1,10)
      DIMENSION MCW(9,50),EHVU(9,50),VU(9,50),DPBT(9,50),MMBTU(9,50),
     +          TYPE(4,50)
      DIMENSION UR(50),CFPU(50),SG(50),HHV(50),HHX(50),VAA(50),VPU(50),
     +WRKC(9), WCST(9),
     +                   CHECK(9),TVBT(9),UTIL(9),AVMH(9),PENI(9),TITLE(14)
      DIMENSION  MC(9),WC(9),ALPHA(9),BETA(9),GAMMA(9),WTLEV(9),PHYS(9),
     +          SPECS(9),WORK(4),FUEL(4),HYCF(9),PRCF(50)
      DIMENSION HUNO(50),HUNME(50),HYVU(50),ACRES(50),VPA(50),HUFC(50),
     +          HVOL(50), IRANK(50),TCF(50)
      DIMENSION HSNO(10),HSNME(10),HPA(10),HSVC(10),FNME(10),FPP(10),
     +           FPU(10),VPFU(10),FPVC(10),COST(10),AAF(10),CEU(10),
     +          AEN(10),EEFU(10),FMV(10)
      DATA   LEVS / 4/
      DATA   WTLIM / 0.65/
      DATA   EVWT / 1.7 /
      DATA   HUGE /1000000000./
      DATA   NINK / 6/
      DATA   ( MC(I),  I=1,6)  / 5,10,20, -5,-10,-20/
      DATA   (WTLEV(L), L=1,4) /0.266, 0.444, 0.546, 0.615 /
      DATA   (ALPHA(I), I=1,5) /.935,1.0019,1.0920,1.3128,1.4646/
      DATA   ( BETA(I),I=1,5) / .18162,.35454,.51232,.87770,1.09615/
      DATA   (GAMMA(I), I=1,5) /.00031,.000345,.000385,.00041,.000445/
      INTEGER  HUNO,HSNO,PNO,FPNO
      REAL MCW,MMBTU,MV,QF,MKT,MKV(50),MKTV(50)
C
C ***                 FORMAT STATEMENTS.    1. INPUT
   10 FORMAT (13A6,A2)
  500 FORMAT (1X,I2, 3X,F4.0,      F10.0,2X,F8.0,3X,I2,5X,F5.2)
  510 FORMAT(A1,I2,1X,A6,4X,A6,3(3X,F7.0),3X,I2,3X,F6.1)
  520 FORMAT(A1,I2,1X,A6,3X,I2,F5.2,3X,F7.0,3A6,A2,5X,F5.0,2(F5.4),F5.2)
  530 FORMAT (A1,I2,1X,A6,4X,F6.2,4X,A6,3(3X,F7.0))
C ***                 FORMAT STATEMENTS.    2. OUTPUT
  600 FORMAT (  // 10X,'PROBLEM SPECIFICATIONS'// 15X,'NUMBER OF HARVEST
     + UNITS',24X,I2 / 15X,'STACK GAS TEMPERATURE',8X,'(DEGREES F)',6X,
     + F4.0/  15X,'ANNUAL HEAT REQUIREMENT',6X,'(     MMBTU)',F10.0/  15X
     +,'OVERHEAD FIXED COSTS', 9X,'(  DOLLARS)',2X,F8.0,/,15X,  'WORKING
     + CAPITAL REQUIREMENT',2X,'(     WEEKS)',6X,I3 / 15X,    'RISK-PROFIT
     +PERCENT REQ.T',22X,F5.2)
  601 FORMAT (  // 10X,'PROBLEM SPECIFICATIONS'// 15X,'NUMBER OF HARVEST
     + UNITS',24X,I2 / 15X,'STACK GAS TEMPERATURE',8X,'(DEGREES F)',6X,
     + F4.0/  15X,'ANNUAL HEAT REQUIREMENT',6X,'(     M#H2O)',F10.0/  15X
     +,'OVERHEAD FIXED COSTS', 9X,'(  DOLLARS)',2X,F8.0,/,15X,  'WORKING
     + CAPITAL REQUIREMENT',2X,'(     WEEKS)',6X,I3 / 15X,    'RISK-PROFIT
     +PERCENT REQ.T',22X,F5.2)
  602 FORMAT('0', 9X,'NOTE: IF STACK GAS TEMPERATURE ENTERED IS LESS THA
     +N 100. DEGREES F., COSTS PER THOUSAND POUNDS OF H2O ',/,16X,'EVAPO
     +RATIVE CAPACITY WILL BE CALCULATED AS FOR DIRECT-FIRED KILN USE. A
     +NNUAL HEAT REQUIREMENTS',/,16X,'MUST BE ENTERED AS NUMBER OF THOUS
     +AND POUNDS OF H2O TO BE REMOVED FROM LUMBER THROUGH KILN.')
  610 FORMAT('1',//,' HARVEST UNIT ',A6,2X,I2,4X,'ACRES',21X,F6.1,3X,'TO
     +TAL CU. FT. AVAIL',1X,F10.1,    'M',/,' INPUT SEQUENCE NO.',2X,I3,4
     +X,'VOL./ACRE IN ',A6,6X,F9.1,3X,'CU. FT., SOLID/UNIT',F11.1,/,' NO
     +. HARVEST SYSTEMS',1X,I3,4X,'HARVEST UNIT FIXED COSTS',F9.0)
```

```
      620 FORMAT(///3X'SYSTEM',4X,'HRS/',2X,'COST/',2X,'PROD',3X,'PERCENT',
     +2X,'UNIT',3X,'SOLID',6X,'UNITS',4X,'PREP',3X,'MKT',3X,'MOIS',4X,'M
     +MBTU',6X,'COST/',4X,'MBTU/',3X,'VAR.',/,13X,'ACRE',2X,'HOUR',3X,'C
     +ODE',4X,'TOTAL',3X,'NAME',3X,'CU.FT./',2X,'AVAILABLE',2X,'COST/',2
     +X,'VAL/',2X,'CONT',2X,'AVAILABLE',4X,'UNIT',5X,'UNIT',4X,'COST/',/
     +,34X,'RECOV',10X,'UNIT',16X,'UNIT',3X,'UNIT',38X,'MMBTU')
      621 FORMAT(///3X'SYSTEM',4X,'HRS/',2X,'COST/',2X,'PROD',3X,'PERCENT',
     +2X,'UNIT',3X,'SOLID',6X,'UNITS',4X,'PREP',3X,'MKT',3X,'MOIS',4X,'M
     +MBTU',6X,'COST/',4X,'MBTU/',3X,'VAR.',/,13X,'ACRE',2X,'HOUR',3X,'C
     +ODE',4X,'TOTAL',3X,'NAME',3X,'CU.FT./',2X,'AVAILABLE',2X,'COST/',2
     +X,'VAL/',2X,'CONT',2X,'AVAILABLE',4X,'UNIT',5X,'UNIT',4X,'COST/',/
     +,34X,'RECOV',10X,'UNIT',16X,'UNIT',3X,'UNIT',38X,'M#H2O')
      630 FORMAT(//,1X,A6,I2,2X,F6.2,F7.0,2X,A6,2X,F6.2,1X,A6,F7.2,3X,F8.0,F
     +8.2,1X,F7.2,2X,F3.2,F10.0,3X,F7.2,F11.2,F6.2)
      640 FORMAT(26X,A6,2X,F6.2,1X,A6,F7.2,2X,F9.0,F8.2,F8.2)
      649 FORMAT ('0',4X,'NOTE. HARVEST SYSTEM ',A6,I2,' DISREGARDED. FUEL '
     + ,A6, 'HAS MOISTURE CONTENT ABOVE THE SPECIFIED LIMIT',F6.2)
      650 FORMAT(//15X,'***',1X,'LEAST COST HARVEST SYSTEM  ',A6,I3,' ***'/
     +25X,'HARVEST UNIT  ',A6,I3//15X,'-FUEL-',20X,'-ENERGY-'//
     +12X,'UNITS AVAIL',4X,F8.0,4X,'MMBTU AVAIL',1X,F10.0,/
     +12X,'FIXED COST',4X,F9.0,4X,'COST/MMBTU',5X,F9.2/
     +12X,'TOTAL COST/UNIT',2X,F8.2)
      660 FORMAT(//1X,'NOTE---M IS THOUSANDS, MM IS MILLIONS.')
      665 FORMAT(' ',4X,'---''''TOTAL COST/UNIT'''' INCLUDES HARVEST UNIT FI
     +XED COST, BUT DOES NOT INCLUDE ''''OVERHEAD FIXED COST'''', OR COS
     +T (INTEREST)',/,11X,'FOR WORKING CAPITAL REQUIREMENT.')
      670 FORMAT('1',1X,'END OF OUTPUT.')
C
C ***     FUEL TYPE DATA AND ESTIMATES OF REQUIREMENTS AND COSTS
       60 FORMAT ('1',  //25X,13A6,A2////)
       61 FORMAT    (19X,'********** FUEL TYPE ASSUMPTIONS AND ESTIMATES OF
     +REQUIREMENTS   AND   COSTS       **********'//46X,'**** HEAT ENERGY
     + SOURCES AND COSTS ****'//97X,'----HEAT-ENERGY VALUES----'/
     +         27X,'UNIT',6X,'UNITS AVAIL.',4X,'CU.FT.',4X,'SPEC.',5X,
     +'M.C.',5X,'$ COST',5X,'HIGHER VALUE',4X,'EFFECTIVE EVAPORATION')
       62 FORMAT     (5X,'********** FUEL TYPE ASSUMPTIONS AND ESTIMATES OF
     +REQUIREMENTS AND COSTS (',F5.0,' DEG.F STACK TEMP.) **********'//
     +                                                46X,'**** HEAT ENERGY
     + SOURCES AND COSTS ****'//97X,'----HEAT-ENERGY VALUES----'/
     +         27X,'UNIT',6X,'UNITS AVAIL.',4X,'CU.FT.',4X,'SPEC.',5X,
     +  'M.C.',5X,'$ COST',5X,'HIGHER VALUE',8X,'HEAT TO STEAM')
       63 FORMAT(27X,'BASIS',7X,'ANNUALLY',6X,'SOLID',5X,'GRAV.',4X,
     +  '(WET)',4X,'PER UNIT ',4X,'MBTU/UNIT ',5X,'MBTU/UNIT ',4X,
     +  '$/MMBTU')
       64 FORMAT(27X,'BASIS',7X,'ANNUALLY',6X,'SOLID',5X,'GRAV=',4X,
     +  '(WET)',4X,'PER UNIT ',4X,'MBTU/UNIT ',5X,'#H2O/UNIT ',4X,
     +  '$/M#H2O')
       70 FORMAT(3X,I2,') ',3A6,A2,A6,4X,F10.0,6X,F6.2,5X,F4.3,3X,F6.4,
     +  4X,'$',F7.2,6X,F8.0,5X,F10.2,4X,'$',F8.2)
       80 FORMAT(/'    PROPOSED SOURCE(S)')
C
C ***                    'PROSPECTUS REQUIREMENTS'
      108 FORMAT(/16X,'**** PROSPECTUS REQUIREMENTS (',F11.0,1X,'  THOUSAND
     + POUNDS OF EVAPORATED WATER/YEAR) AND AVERAGE COST/M H2O ****'/)
      109 FORMAT(/16X,'**** PROSPECTUS REQUIREMENTS (',F11.0,
     + 1X,'MILLION STEAM-HEAT BTU S/YEAR) AND AVERAGE COST/MMBTU ****'/)
      110 FORMAT(43X,'--------ANNUAL VOLUMES REQUIRED AT VARIOUS MOISTURE CO
     +NTENTS (WET BASIS)--------'//
     +4X,'PROPOSED SOURCES',8X,'UNIT',7X,
     + 'AT GIVEN',11X,'AT HIGHER MOISTURE CONTENT*',
     +14X,'AT LOWER MOISTURE CONTENT**'/27X,'BASIS',8X,'M.C.',11X,
     +  '+5 PCT.',4X,'+10 PCT.',4X,'+20 PCT.',10X,'-5 PCT.',4X,
     +  '-10 PCT.',4X,'-20 PCT.'/)
      160 FORMAT                          (4X,I2,')',1X,3A6,A2,A6,4X,F8.1,
     +  8X,F8.1,2(4X,F8.1),9X,F8.1,2(4X,F8.1))
      190 FORMAT( ' **** WITH MOISTURE CONTENT CHANGED ',I3,' PCT. (WET BASI
     +S), THERE IS AN ANNUAL DEFICIT OF ',F11.1,13H MMBTU'S ****)
      191 FORMAT(' ',4X,'---COSTS INCLUDE ''''OVERHEAD COST'''' AND WORKING
     +CAPITAL COST(INTEREST).')
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      219 FORMAT('0',3X,'AVG. COST/M#H20',17X,'$',F9.2,6X,'$',F9.2,2(2X,'$',
         +F9.2),7X,'$',F8.2,2(2X,'$',F9.2))
      220 FORMAT('0',3X,'AVG. COST/MMBTU',20X ,'$',F7.2,8X,'$',F7.2,2(4X,
         +  '$',F7.2),9X,'$ ',F6.2,2(4X,'$',F7.2))
      230 FORMAT(/4X,'EST.D  TOTAL  COSTS',16X,'$',F6.1,'M',8X,'$',F6.1,
         +  2('M',4X,'$',F6.1),'M',9X,'$',F6.1,2('M',4X,'$',F6.1),'M'//)
      234 FORMAT(/4X,'WORKING CAPITAL REQ',16X,'$',F6.1,'M',8X,'$',F6.1,
         +  2('M',4X,'$',F6.1),'M',9X,'$',F6.1,2('M',4X,'$',F6.1),'M'//)
      233 FORMAT(' * WOOD FUEL CALCULATIONS ASSUME 40-PCT EXCESS AIR AND 4-P
         +CT HEAT LOSS FROM UNBURNED '/' FUEL, RADIATION AND UNACCOUNTED LOS
         +SES.  THE PROGRAM ALLOWS WOOD FUEL MOISTURE'/' CONTENTS TO DROP BE
         +LOW 0-PCT BUT DISQUALIFIES A FUEL TYPE WHEN MOISTURE CONTENT'/
         +' EXCEEDS 65-PCT.')
      232 FORMAT(' ******** DUE TO A BTU DEFICIT, THIS CALCULATION IS NOT ME
         +ANINGFUL.'/)
      231 FORMAT(' * CALCULATIONS ASSUME A KILN EVAPORATIVE RATE OF  ',
         +F5.3,' M',                                                      '
         + BTUS PER POUND'/' OF EVAPORATED WATER.  EFFECTIVE EVAPORATIVE CAP
         +ACITIES FOR WOOD/BARK FUELS ARE'/' ADJUSTED FOR FUEL MOISTURE CONT
         +ENT.  THE PROGRAM ALLOWS WOOD FUEL MOISTURE'/' CONTENT TO DROP BEL
         +OW ZERO-PCT BUT DISQUALIFIES A FUEL TYPE WHEN MOISTURE'/' CONTENT
         +EXCEEDS 65-PCT.'/)
    C ***                FORMAT STATEMENTS.   3. ERROR MESSAGES
      555 FORMAT ('0',10X,'ERROR.  NUMBER OF HARVEST UNITS IS NOT SPECIFIED
         +IN THE PROGRAM AND DATA CONTROL CARD.')
      560 FORMAT('0',10X,'ERROR.  INCORRECT CARD TYPE CODE.  SHOULD BE HAR',
         + 'VEST UNIT CARD.  INPUT SEQUENCE NUMBER ',I2)
      565 FORMAT('0',10X,'ERROR.  NUMBER OF HARVEST SYSTEMS NOT SPECIFIED IN
         + HARVEST UNIT CARD. INPUT SEQUENCE NUMBER ',I2)
      570 FORMAT('0',10X,'ERROR.  INCORRECT CARD TYPE CODE. SHOULD BE HAR',
         + 'VEST SYSTEM CARD.INPUT SEQUENCE NUMBERS',I3,'.',I1)
      575 FORMAT('0',10X,'ERROR.  NUMBER OF PRODUCTS RECOVERED NOT SPECIFIED
         + IN HARVEST SYSTEM CARD. INPUT SEQ. NUMBERS',I3,'.',I1)
      580 FORMAT('0',10X,'ERROR.  INCORRECT CARD TYPE CODE.  SHOULD BE H.S.
         +FUEL PRODUCT CARD. INPUT SEQUENCE NUMBERS',I3,'.',I1)
      590 FORMAT('0',10X,'ERROR.  FUEL PRODUCT RECOVERY PERCENT INCORRECTLY
         +SPECIFIED. INPUT SEQUENCE NUMBERS',I3,'.',I1 )
      595 FORMAT('0',10X,'ERROR.  INCORRECT CARD TYPE CODE.  SHOULD BE NON-'
         + ,'FUEL PRODUCT CARD. INPUT SEQ. NUMBERS',I3,'.',I1,'.',I1)
    C
          READ   (5, 10)   (TITLE(I),  I=1,14)
          WRITE  (6,60)  (TITLE(I),I=1,14)
    C
    C *** READ IN PROGRAM AND DATA CONTROL CARD.
          READ  (5,500)  NHU, STKT, AHR, FCO, NWC, RPR
          IF  (NHU.GE.1)  GO  TO  501
          WRITE  (6,555)
          GO  TO  599
      501 CONTINUE
    C
    C *** PRINT OUT PROBLEM SPECIFICATIONS
    C
          IF(STKT.GE.100.0) WRITE(6,600) NHU,STKT,AHR,FCO,NWC,RPR
          IF(STKT.LT.100.0) WRITE (6,601) NHU,STKT,AHR,FCO,NWC,RPR
          WRITE  (6,602)
          N=0
      502 CONTINUE
          N = N + 1
    C *** READ IN HARVEST UNIT HEADER CARD.
          READ(5,510) CARD, HUNO(N), HUNME(N), HYVU(N), ACRES(N), VPA(N),
         + HUFC(N), NHS, HYCF(N)
          IF(HYCF(N).LT.0.5) HYCF(N) = 1.0
          TCF(N) = (ACRES(N) * VPA(N) * HYCF(N))/1000.
          IF  (CARD.EQ.'U')  GO  TO  504
          WRITE  (6,560)  N
          GO  TO  599
      504 CONTINUE
          IF  (NHS.GE.1)  GO  TO  506
          WRITE  (6,565)  N
          GO  TO  599
```

```
      506 CONTINUE
          IF   (HUNO(N).EQ.0)  HUNO(N) = N
          IF   (HYVU(N).EQ.'        ')  HYVU(N) = 'CU.FT.'
    C
    C *** PRINT OUT HARVEST UNIT CONSTANTS
    C
          WRITE(6,610)HUNME(N),HUNO(N),ACRES(N),TCF(N),N,HYVU(N),VPA(N),
         +HYCF(N),NHS,HUFC(N)
    C
    C *** PRINT OUT HARVEST SYSTEM HEADINGS
    C
          IF(STKT.GE.100.) WRITE(6,620)
          IF(STKT.LT.100.) WRITE(6,621)
          HVOL(N) = ACRES(N) * VPA(N)
          M = 0
          MBEST = 0
          BEST = HUGE
          DO 507 I=1,6
      507 SPECS(I) = 0.
      508 CONTINUE
          M = M + 1
    C *** READ IN HARVEST SYSTEM DATA CARD.
          READ(5,520)CARD,HSNO(M),HSNME(M),NPR,HPA(M),HSVC(M),(WDBK(I),I=1,4
         +),(PHYS(I),I=1,4)
          IF   (CARD.EQ.'S')  GO  TO  511
          WRITE  (6,570)  N, M
          GO  TO  599
      511 CONTINUE
          IF   (NPR.GE.1)  GO  TO  512
          WRITE  (6,575)  N, M
          GO  TO  599
      512 CONTINUE
          IF   (HSNO(M).EQ.0)  HSNO(M) = M
    C *** READ IN HARVEST SYSTEM FUEL PRODUCT CARD.
          READ  (5,530)  CARD, FPNO, FNME(M), FPP(M),  FPU(M), PRCF(M),
         + FPVC(M), FMV(M)
           IF(PRCF(1).LT.0.5) PRCF(1) = 72.0
          IF(PHYS(1).LT.0.5) PHYS(1) = PRCF(1)
          VPFU(M) = PRCF(M)/HYCF(N)
          IF   (CARD.EQ.'F')  GO TO 514
          WRITE  (6,580)  N, M
          GO  TO  599
      514 CONTINUE
          IF   (FPNO.LE.0)   FPNO = 1
          MFPP = IFIX(FPP(M))
          IF   (MFPP.GT.0)  GO  TO  518
          WRITE  (6,590)  N, M
          GO  TO  599
      518 CONTINUE
          PRPCST = FPVC(M)
          QF = (FPP(M)/100.) / VPFU(M)
          JJ = NPR - 1
    C
    C *** TEST FOR MORE PRODUCTS OTHER THAN FUEL
    C
          IF   (JJ.EQ.0)  GO  TO  527
          J = 0
      522 CONTINUE
          J = J + 1
    C *** READ IN NON-FUEL PRODUCT CARD
          READ(5,530) CARD, PNO(1,J), PNME(1,J), PP(1,J), PUNME(1,J),
         +                PUCF(1,J), PPVC(1,J), MV(1,J)
          VUEQ(1,J) = PUCF(1,J)/HYCF(N)
          PUAV(1,J) = ((TCF(N) * PP(1,J))/ PUCF(1,J))*10.0
          IF   (CARD.EQ.'P')  GO  TO  524
          JP = J + 1
          WRITE  (6,595)  N, M, JP
          GO  TO  599
      524 CONTINUE
          IF(PNO(1,J).EQ.0) PNO(1,J)=J+1
          IF(PUNME(1,J).EQ.'        ') PUNME(1,J)= 'CU.FT.'
```

```
      IF(VUEQ(1,J).LE.0.0) VUEQ(1,J)=1.0
C
C *** TEST FOR ANOTHER NON-FUEL PRODUCT
C
      IF  (J.LT.JJ)  GO  TO  522
      DO 526  J = 1,JJ
      QJ = (PP(1,J)/100.) / VUEQ(1,J)
      QJF = QJ / QF
      MKT = MKT + MV(1,J) * PUAV(1,J)
      PRPCST = PRPCST + (PPVC(1,J) - MV(1,J)) * QJF
  526 CONTINUE
  527 CONTINUE
C
C *** COMPUTE HARVEST SYSTEM COST AND BTU'S PER UNIT
C
      AAF(M) = HVOL(N) * QF
      HRVCST = ACRES(N) * HPA(M) * HSVC(M) / AAF(M)
      COST(M) = HRVCST + PRPCST
      MKTV(M) = MKT
      CALL  BOILER( STKT, EVRT, LEVS, WTLEV, WTLIM, PHYS, ALPHA, BETA,
     + GAMMA, MFLAG)
      IF  (MFLAG.EQ.0)  GO  TO  528
      WRITE  (6,649)  HSNME(M), HSNO(M), FNME(M), WTLIM
      GO  TO  533
  528 CONTINUE
      ENGY = PHYS(6)
      CEU(M) = 1000. * COST(M) / ENGY
      AEN(M) = (AAF(M) * ENGY) / 1000.
      EEFU(M)=ENGY
      IF  (CEU(M).GE.BEST)  GO  TO  532
      BEST = CEU(M)
      MBEST = M
      DO 529  I=1,4
  529 FUEL(I) = WDBK(I)
      DO 531 I = 1,6
  531 SPECS(I) = PHYS(I)
  532 CONTINUE
  533 CONTINUE
C
C *** PRINT OUT SYSTEM VALUES FOR FUEL AND HARVEST SYSTEM RESULTS
C
      WRITE(6,630)HSNME(M),HSNO(M),HPA(M),HSVC(M),FNME(M),FPP(M),FPU(M),
     +PHYS(1),AAF(M),FPVC(M),FMV(M),PHYS(2),AEN(M),COST(M),EEFU(M),CEU(M
     +)
C
C *** WRITE NON-FUEL PRODUCT VALUE
C
      IF (NPR .EQ. 1) GO TO 535
      DO 534 J=1,JJ
  534 WRITE(6,640) PNME(1,J), PP(1,J), PUNME(1,J), PUCF(1,J), PUAV(1,J),
     +PPVC(1,J),MV(1,J)
C
C *** TEST FOR ANOTHER HARVEST SYSTEM DATA CARD
C
C
  535 IF  (M.LT.NHS)  GO  TO  508
  536 CONTINUE
      DO  537  I=1,4
  537 TYPE(I,N) = FUEL(I)
      MKV(N) = MKTV(MBEST)
      UP(N) =  FPU(MBEST)
      CFPU(N) = SPECS(1)
      MCW(1,N) = SPECS(2)
      SG(N) = SPECS(3)
      HHV(N) = SPECS(4)
      HHX(N) = SPECS(5)
      EHVU(1,N) = SPECS(6)
      VAA(N) = AAF(MBEST)
      VPU(N) = COST(MBEST) + HUFC(N) / AAF(MBEST)
      MMBTU(1,N) = AEN(MBEST)
```

```
      DPBT(1,N) = (VPU(N) / EEFU(MBEST)) * 1000.
C     DPBT(1,N) = CEU(MBEST) + HUFC(N) / AEN(MBEST)
C *** PRINT OUT LEAST COST HARVEST SYSTEM
C
      WRITE(6,650) HSNME(MBEST),HSNO(MBEST),HUNME(N),HUNO(N),VAA(N),
     +             MMBTU(1,N),HUFC(N),DPBT(1,N),VPU(N)
      WRITE(6,660)
      WRITE (6,665)
      IF  (N.LT.NHU)  GO  TO  502
C
C *** DEFINE MOISTURE INCREMENTS FOR SENSITIVITY ANALYSIS
      DO 48 I=1,NINK
      WC(I) = MC(I)
   48 WC(I) = WC(I) / 100.
C
C
C *** COMPUTE EFFECTIVE HEATING VALUE AND MMBTU'S AVAILABLE ANNUALLY
C ***   PER STANDARD UNIT
      DO 50 N=1,NHU
      PHYS(1) = CFPU(N)
      PHYS(3) = SG(N)
      PHYS(4) = HHV(N)
      DO 51 K=1,NINK
      J = K + 1
      MCW(J,N) = MCW(1,N) + WC(K)
      PHYS(2) = MCW(J,N)
      CALL  BOILER( STKT, EVRT, LEVS, WTLEV, WTLIM, PHYS, ALPHA, BETA,
     + GAMMA, MFLAG)
      EHVU(J,N) = PHYS(6)
      IF  (MFLAG.EQ.1)  GO TO 52
      DPBT(J,N) = (VPU(N)/EHVU(J,N)) * 1000.0
   52 MMBTU(J,N) = (EHVU(J,N)*VAA(N))/1000.0
   51 CONTINUE
   50 CONTINUE
C
C *** RANKING SEQUENCE (TO RANK OPTIONS IN TERMS OF LEAST COST PER
C ***  EFFECTIVE MMBTU'S AT GIVEN MOISTURE CONTENT)
C
      IF  (NHU.LE.1)   GO  TO  133
      LIMIT = NHU - 1
      DO 120 N=1,NHU
      IRANK(N) = N
  120 CONTINUE
      DO 125 INDEX=1,LIMIT
      IBEST = IRANK(INDEX)
      IPLUS = INDEX + 1
      ISTAR = 0
      DO 130 I=IPLUS,NHU
      II = IRANK(I)
      IF  (DPBT(1,II) - DPBT(1,IBEST))  129, 130, 130
  129 ISTAR = I
      IBEST = II
  130 CONTINUE
      IF  (ISTAR.GT.0)  IRANK(ISTAR) = IRANK(INDEX)
      IRANK(INDEX) = IBEST
  125 CONTINUE
  133 CONTINUE
C
C *** COMPUTE VOLUMES OF RESOURCES REQUIRED
C
      DO 151 J=1,7
      CHECK(J) = AHR
      DO 150 K=1,NHU
      N = IRANK(K)
      CHECK(J) = CHECK(J) - MMBTU(J,N)
      IF(CHECK(J).GT.0.0) VU(J,N) = VAA(N)
      IF(CHECK(J).LT.0.0) VU(J,N) = ((CHECK(J)+MMBTU(J,N))*1000.0) /
     +  EHVU(J,N)
      IF(MCW(J,N).GT.WTLIM)  VU(J,N) = 0.0
      IF(VU(J,N).LT.0.0) VU(J,N) = 0.0
```

```
  150 CONTINUE
  151 CONTINUE
C
C *** COMPUTE AVERAGE VCOST/MMBTU'S (AVMB) AND TOTAL COST (BENI)
C
      J = 1
  200 TVBT(J)=FCO
      UTIL(J)=0.
      DO 210 K=1,NHU
      N = IRANK(K)
      TVBT(J) = (VU(J,N)*VPU(N)) + TVBT(J)
      WRKC(J)= ((NWC*VU(J,N))/(52.0*VAA(N))*(TVBT(J)+MKV(N)))+WRKC(J)
      UTIL(J) = ((EHVU(J,N)*VU(J,N))/1000.0) + UTIL(J)
  210 CONTINUE
      WCST(J)=WRKC(J)*RPR
      TVBT(J) = TVBT(J) + WCST(J)
      WRKC(J) = WRKC(J) /1000.0
      BENI(J) = TVBT(J)/1000.0
      AVMB(J) = TVBT(J)/UTIL(J)
      J = J + 1
      IF(J.LT.8) GO TO 200
C
C *** FUEL TYPE DATA FOR EACH HARVEST UNIT
C
      WRITE  (6,60)  (TITLE(I),I=1,14)
      IF(STKT.LE.100.0) WRITE(6,61)
      IF(STKT.GT.100.0) WRITE(6,62) STKT
      IF(STKT.GT.99.9) WRITE(6,63)
      IF(STKT.LT.100.0) WRITE(6,64)
      WRITE(6,80)
      DO 90 K=1,NHU
      N = IRANK(K)
      WRITE(6,70) K,(TYPE(I,N),I=1,4),UB(N),VAA(N),CFPU(N),
     +         SG(N),MCW(1,N),VPU(N),HHX(N),EHVU(1,N),DPBT(1,N)
   90 CONTINUE
      WRITE(6,660)
C
C ***                    'PROSPECTUS REQUIREMENTS'
C
      WRITE (6,60)   (TITLE(I),  I=1,14)
      IF(STKT.LE.100.0) WRITE (6,108) AHR
      IF(STKT.GT.99.9) WRITE (6,109) AHR
      WRITE(6,110)
      DO 171 K=1,NHU
      N = IRANK(K)
      WRITE(6,160) K,(TYPE(I,N),I=1,4),UB(N),(VU(J,N),J=1,7)
  171 CONTINUE
      IF(STKT.LT.100.0) WRITE(6,219) (AVMB(J), J=1,7)
      IF(STKT.GT. 99.9) WRITE (6,220)(AVMB(J), J=1,7)
      JJ = 0
      DO 172 J=1,7
      IF(CHECK(J).LE.0.0)  GO TO 172
      JJ = 1
      BENI(J) = HUGE
  172 CONTINUE
      WRITE(6,230) (BENI(J),J=1,7)
      WRITE(6,234) (WRKC(J),J=1,7)
      IF(STKT.LT.100.0) WRITE(6,231), EVRT
      IF(STKT.GT. 99.9) WRITE(6,233)
      IF(JJ.EQ.1) WRITE(6,232)
      DO 180 J=1,7
      IF(CHECK(J).GT.0.0) WRITE(6,190) MC(J),CHECK(J)
  180 CONTINUE
C
      WRITE(6,660)
      WRITE (6,191)
  599 CONTINUE
      WRITE(6,670)
      STOP
      END
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The Forest Products Laboratory (USDA Forest Service) has served as the national center for wood utilization research since 1910. The Laboratory, on the University of Wisconsin-Madison campus, has achieved worldwide recognition for its contribution to the knowledge and better use of wood.

Early research at the Laboratory helped establish U.S. industries that produce pulp and paper, lumber, structural beams, plywood, particleboard and wood furniture, and other wood products. Studies now in progress provide a basis for more effective management and use of our timber resource by answering critical questions on its basic characteristics and on its conversion for use in a variety of consumer applications.

Unanswered questions remain and new ones will arise because of changes in the timber resource and increased use of wood products. As we approach the 21st Century, scientists at the Forest Products Laboratory will continue to meet the challenge posed by these questions.

Forest Products Laboratory 75th Anniversary 1910 1985